

Research on the Combination of Electromagnetic Voltage Transformer and Straight-through Current Transformer

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Abstract: The working principle of the current transformer is similar to that of the transformers, which converts the large current into a small current in a certain proportion, provides the current for the use of various instruments and relay protection, and separates the secondary system from the high voltage. The nonlinear ferromagnetic characteristic of voltage transformer is the fundamental cause of ferroresonance. Since the current transformer does not have a primary winding, the change ratio is determined by the number of turns passing through the iron center of the transformer. The paper presents research on the combination of electromagnetic voltage transformer and straight-through current transformer.

1. Introduction

The current transformer is a kind of electrical device which is composed of secondary circuit and is not in series in the main circuit. In general, the current transformer is used in the case that the current of the main circuit is larger than the withstand capacity of the meter [1]. When the current of the main circuit is greater than 5A, the current ratio of the main circuit is reduced by using the current transformer to reduce the proportion of the current of the main circuit.

Multi-tap current transformer. In this type of current transformer, the primary winding is invariant, and several taps are added to obtain several different ratios when winding the secondary winding. It has a core and a primary winding with fixed number of turns. The secondary winding is wound on an insulating cylinder which is set on the iron core by insulated copper wire. The tap of the secondary winding with different ratios is drawn out and connected to the terminal seat of the connection. Each tap sets its own terminal, thus forming multiple variable ratios.

If the secondary overload of the voltage transformer, the summation of the secondary load current will exceed the rated value, which will cause the internal winding heating of the voltage transformer to increase, especially if the voltage is higher than the rated voltage, the internal heating of the voltage transformer is more serious [2]. Furthermore, the system belongs to the neutral point non-effective grounding system, so the primary side voltage is prone to skew in operation. When a certain phase has high voltage, the phase voltage transformer is more prone to thermal expansion burst.

The principle of comparative testing: applying high current (voltage) to the primary side of the standard transformer with the same transformer ratio, collecting the current (voltage) signal collected from the secondary side of the transformer, and inputting the signal into the inner of the calibrator for the relevant difference calculation. The data obtained by the instrument are the error data of transformer. When measuring the error of transformer in this principle, large equipment such as standard current (voltage) transformer, rising current (voltage) device, load box and so on need to be used. The connection is complicated, the safety hidden danger exists in the rising current (pressure), the work efficiency of carrying out the inspection in the field is low, extremely inconvenient.

There is a certain error in the conversion current of the current transformer. According to the error of changing ratio produced by the current transformer under the rated working condition, the

accurate grade is defined. The current transformer above class 0.1 is mainly used in the test. Precision measurement or calibration of low grade transformers can also be used in conjunction with standard instruments, often referred to as standard current transformers.

The characteristic of this kind of current transformer is that it has many variable ratio ranges and can be changed, which is more common in high voltage current transformer. The primary winding is divided into two sections, passing through the iron core of the transformer, and the secondary winding is divided into two independent windings with tap head and different degrees of accuracy.

The error of current transformer is mainly composed of variable ratio error and load error, so when the detected current transformer belongs to nonlinear error compensation, As long as the actual turn ratio (n_2/n_1) of the measured CT is accurately measured, the no-load error of the transformer under the small current signal, the internal impedance of the secondary winding, and the excitation admittance at other current points are measured, Thus, the actual error of this type of transformer can be calculated.

2. Structure principle and Application Analysis of current Transformer

When the current exceeds a certain value, the electric meter and other measuring instruments should be connected to the circuit through the current transformer, so that the measuring instrument and the staff can avoid direct contact with the high current circuit, thus ensuring the safety of the instrument and the person [3]. It is also easy to standardize the instrument manufacture and expand the measuring range by using the transformer, and the accuracy of the instrument can be improved easily.

The combined current-voltage transformer is the primary, secondary winding and the primary and secondary winding of the two or three current transformers and the primary, secondary winding and iron core of the voltage transformer, which are fixed on the steel frame and immersed in the box containing transformer oil. Secondary winding out of the wire, connected to the box outside the high, low-voltage porcelain bottle, the formation of insulation, closed whole.

The secondary side of the current transformer in operation is not allowed to open circuit, in the secondary side cannot install fuses, knife switches. This is because the number of secondary winding turns of current transformer is much larger than that of primary side winding. In the open circuit condition, the current transformer is equivalent to a boost transformer.

The rated primary current of the current transformer varies according to the normal current in different circuits, but the rated secondary current of the current transformer is standardized, with only 1A and 5A. In this paper, the secondary capacity of the current transformer for measuring and maintaining the current at different transmission distances is calculated respectively for these two kinds of currents.

The current transformer is to measure the AC current. When connecting with the ammeter, if the three current transformers are connected to the three ammeters, the two ends of the current transformers and the two ends of the ammeter can be connected, as is shown by equation(1) [4].

$$Z_{A12} = n^2 \times \frac{Z_L \cdot R_D}{n^2 Z_L + R_D} \quad (1)$$

The rated current standard ratio of primary side of current transformer (such as 20 / 30, 4050 / 75 / 100) and $1502 \times a / C$, etc., is usually 1A or 5A for secondary side rated current. Among them, $2 \times a / C$ indicates that the same product has two current ratios, which can be realized by changing the connection mode of the product. When connected in series, the current ratio is a / c , and the current ratio in parallel is $2 \times a / C$. In general, the current conversion ratio of metering current transformer should be chosen so that the primary rated current I_n should not be less than the load current in the line (that is, the calculation of IC).

High voltage three-phase systems, especially 10KV three-phase systems, which are widely used in neutral point insulation systems or high voltage three-phase systems grounded by arc-suppression coils, especially 10KV three-phase systems, are connected from triangular connections, but "ports"

are not closed, so they are called Vv connections. This connection mode can save a voltage transformer and meet the requirements of three-phase active and reactive power metering, but it cannot be used to measure the phase voltage and cannot be connected to the voltmeter to monitor the insulation condition of the system.

The load of the current transformer usually consists of two parts: one is the connected measuring instrument or protective device, the other is the connecting wire. When calculating the load of current transformer, attention should be paid to the conversion coefficient of impedance in different connection mode and fault state.

If the voltage transformer bears a high rating, it will directly cause the insulation medium to be heated and vaporized, and the volume will expand rapidly, while the inner space of the dry type voltage transformer is limited, which will burst when the pressure increases to a certain extent. And overvoltage can be divided into external overvoltage and internal overvoltage [5]. The external overvoltage is mainly caused by lightning strike, as is shown by equation(2).

$$E[\tilde{X}\tilde{X}^T] = C_x - C_x H^T (H C_x H^T + C_v)^{-1} H C_x \quad (2)$$

According to the rated current size of the motor, select the corresponding current transformer, for example: 30 kilowatt motor rated current about 60 A, you can choose 100 / 5 current transformer. Then the current transformer K₁ K₂ is connected to the upper and lower end of the main contact point of the heat relay with setting current size 3A. Finally, the output of the thermal relay is serially connected to the contactor coil of the motor. Note that current transformer K₂ should be grounded.

Based on the testing principle, the instrument is portable, easy to connect and high safety. However, most of the portable calibrators in the market have a single function and poor field anti-interference, that is, a single device can only test current transformer or voltage transformer, which is easy to be affected by field electromagnetic interference.

3. Excitation impedance analysis of voltage transformer

According to the equivalent circuit diagram of the voltage transformer and the classical error theory, it is known that due to the existence of excitation current, winding resistance and reactance, the transformer in the measurement is caused by the difference between the actual change ratio and the rated change ratio. The deviation of secondary voltage phase produces voltage ratio error and phase error.

Internal overvoltage usually includes operating overvoltage and resonant overvoltage. If the switch is operated within the system, the power system will transition from one stable state to another. Due to the oscillation, exchange and redistribution of the electromagnetic energy in the power system, it is possible to generate large overvoltages in some equipment, even in the whole power system.

Here the three-phase voltage transformer with three core columns is mainly used in the high-voltage three-phase system with small current grounding. The secondary neutral connection leads to the grounding [6]. In order to prevent the single-phase earthling fault on the high-voltage side, the neutral point on the high-voltage side is not allowed to be grounded. Therefore, the voltage to the ground cannot be measured.

The principle of selecting accurate level: the accurate level of current transformer used for charging and metering is not less than 0.5; the current meter used to monitor the load current in each line circuit should be used as current transformer of class 1.0-3.0. In order to ensure that the accuracy error does not exceed the specified value, the secondary load (voltammeter) of the current transformer is generally checked, and S₂ of the secondary load of the transformer is not greater than the rated load S_{2n}. the accuracy of the selection can be guaranteed.

If it is measured by three current transformers, a current meter is used to display them, and a special conversion switch is required. This kind of switch is special: the short circuit state of the other two phase current transformers is measured when a certain phase current is measured.

When the current transformer is installed, the polarity (same name end) should be paid attention to. The terminal of the primary side is L1 / L2 (or P1 / L2), and the primary side current flows in from L1 and out of L2. The terminal of the secondary side is K1OK2 (or S1KS2), that is, the terminal of the secondary side flows out from K1 and flows in by K2. L1 and K1 L2 and K2 are the same polarity (the same end). Otherwise, if the watt-hour meter is connected with the watt-hour meter, the watt-hour meter will reverse.

The structure of the piercing current transformer does not have a primary winding, and the current carrying (load current) conductor passes from L1 to L2 through the circular (or other shape) iron core made of silicon steel rolled out [7]. The secondary winding is directly and uniformly wound on the circular core, which is connected in series with the secondary load of the current coil such as instrument, relay and transmitter to form a closed loop.

The working principle of the current transformer is similar to that of the transformer, which converts the large current into a small current in a certain proportion, provides the current for the use of various instruments and relay protection, and separates the secondary system from the high voltage. It not only guarantees the safety of personal and equipment, but also simplifies and standardizes the manufacture of instruments and relays.

The nonlinear ferromagnetic characteristic of the voltage transformer is the fundamental cause of the ferroresonance. The excitation impedance of the voltage transformer is very large during normal operation, the network impedance to the ground is that, and the three-phase is basically balanced.

4. Research on the combination of electromagnetic Voltage Transformer and straight-through current Transformer

In normal operation, the voltage at the output end of the trigonometric opening is zero. If one phase is connected to the system, the output voltage of the other two output terminals is three times the secondary voltage of each phase residual voltage winding, and the output voltage of the other two output terminals is 3 times that of the secondary voltage of each phase residual voltage winding. This facilitates voltage setting for AC insulation monitoring voltage relays, but this connection is not used in 10KV and below systems.

The secondary rated capacity of the current transformer is larger than that of the actual secondary load, and the actual secondary capacity should be 25% 100%. Capacity determines the secondary load impedance, which in turn affects the measurement or control accuracy. The load impedance is mainly affected by the resistance of the measuring instrument and relay coil, reactance and wiring contact resistance, and the resistance of the secondary connection wire.

When the secondary coil of the current transformer is closed, the magnetic potential of the secondary winding cancels each other, the magnetic flux in the core is very small and the inductive potential on both sides is very low, so it will not affect the work of the load. If the secondary winding is open, the magnetic potential of the primary winding will greatly increase the magnetic flux of the iron core, and the number of turns of the secondary winding will be increased, so that the inductive potential of the secondary unit will be very high, and the insulation will be broken down, the equipment will be damaged and the safety of the surveyor will be endangered.

Because the current transformer does not have a primary winding, the ratio is determined according to the number of turns passing through the iron center of the transformer. The more the number of turns through the center, the smaller the ratio of change [8]. On the other hand, the smaller the number of turns through the center, the greater the ratio of variation, the rated current ratio is the following formula.

$$u^{(1)} = R \times \frac{\dot{I}_A + \dot{I}_C}{n \times n_2} = \frac{R \times 4.33 \angle -60^\circ}{n_2} \quad (3)$$

When the secondary current of the current transformer is 1A, the secondary capacity of 10VA can be selected, and the transmission distance of the cable with 2.5 mm² section can be at least 200m, while when the secondary current of the current transformer is 5A, If the cable with 2.5 mm² section

is used for transmission, the transmission distance will not reach 100m when the secondary capacity of 30VA is selected. Therefore, the cable with 2.5 mm² sections should not be used in accordance with the requirements of the code, at least the cable of 4mm² section should be used. If the transmission distance is less than 100m, the secondary capacity of 30VA current transformer can be selected.

The primary side winding of current transformer is divided into single turn and multi turn, LQG type is single turn. When using the LMZ type, we should pay attention to whether there is the piercing data on the nameplate, and if so, the required number of turns. Note: the number of turns through the center is determined by the number of roots passing through the empty center, not by the number of turns in the periphery (otherwise, it will be a turn of error).

However, under some disturbances, such as the occurrence and disappearance of single-phase grounding fault, or the occurrence of single-phase arc grounding, the three-phase core of the voltage transformer is saturated with different degrees of excitation, and the phase inductance changes. Due to the continuous increase of the line current, the core of the voltage transformer is gradually saturated.

Combined type transformer is composed of current transformer and voltage transformer. It is installed in high voltage metering box and cabinet. It can be used to measure electric energy or be used as power supply for relay protection device of electric equipment.

5. Summary

In a word, ferromagnetic resonance overvoltage is a great threat to the insulation of voltage transformer. It is not necessary to misjudge the resonance of voltage transformer as single-phase grounding and delay the time of timely and accurate processing. Measuring the current of single-phase power supply, the connection between current transformer and ammeter, as long as the two ends of the current transformer and the two ends of the ammeter can be connected, the same cannot be divided, tail. The selection of current transformer capacity should be combined with practical requirements, not as much as possible. Only when the selected secondary capacity is close to the actual secondary load, the accuracy of current transformer is higher and larger or smaller capacity will affect the measurement accuracy.

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